

***Echinococcus granulosus* in wolves in Idaho**

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The parasite

The family of tapeworms that are of most importance to man and carnivores are the Taeniidae. This group of parasites includes the genera *Taenia*, *Multiceps* and *Echinococcus*. The genera are distinguished by morphology of the adult tapeworm and the form of the immature worm in the intermediate host. There are currently two Holarctic species of *Echinococcus*, *Echinococcus granulosus* and *E. multilocularis*, and two Neotropical species, *E. oligarthrus* and *E. vogeli*.

Echinococcus granulosus has a two host life cycle with canids as the definitive host for adult worms and ungulates as the intermediate host for the larval worms. The adult worms are small, about 3-5 mm in length, and live in the small intestine of canids (dogs, wolves, foxes, dingo, and jackals). The adult worms lay eggs that are passed in the feces of the canid and are accidentally ingested by ungulates (deer, elk, moose, caribou, domestic sheep, domestic cattle, etc) where the eggs hatch in the rumen and migrate to the thoracic or abdominal cavity and form sac like structures called hydatid cysts. Within the hydatid cysts, hundreds of immature tapeworms bud off the lining of the cyst. If a canid consumes a hydatid cyst, the larval tapeworms develop into adult worms in the small intestine of the canid.

Echinococcus granulosus has a worldwide distribution (Gottstein 1992). There are two recognized biotypes of the parasite – the northern or sylvatic biotype that circulates between canids (wolf, dog) and cervids (moose, caribou, reindeer, deer and elk) and is present above 45° latitude. The northern biotype does not appear to cross-infect domestic livestock (Rausch 1986).

The domestic biotype, comprised of at least nine different strains, circulates between dogs and domestic ungulates, especially sheep or other endemic species of wildlife (lions and sheep, dingoes and dogs and macropod marsupials, etc) (Jones and Pybus 2001). It is endemic in most sheep raising areas of the world including the southwestern United States, central and South America, the Middle East, northern Africa, and Australia (Loveless et al. 1978; Jones and Pybus 2001).

Echinococcus multilocularis has a two host life cycle with canids as the definitive host for adult worms and rodents as the intermediate host for the larval worms. The adults are small and live in the small intestine of dogs, foxes and cats. The eggs are passed in the feces and accidentally ingested by small rodents, primarily mice and voles, in which the eggs hatch and migrate to the abdominal cavity and form multicompartmental hydatid cysts called alveolar or multilocular cysts. If a canid consumes a multilocular cyst, the larval tapeworms develop into the adult worms in the small intestine of the canid.

Echinococcus multilocularis has a worldwide distribution in the northern hemisphere (Gottstein 1992) and is endemic in south central Canada and the northern Midwestern states in the United States (Leiby et al. 1970).

The parasite in Idaho

Slaughter surveys of domestic sheep for hydatid cysts are not typically done and liver cysts found are not differentiated into species of parasite present. *Echinococcus granulosus* has been

documented in domestic sheep from Idaho that were sent to California to slaughter (Sawyer et al. 1969). Infection rates varied from 25-60% in lots averaging 141 head at that time. Additional evidence of the presence of *E. granulosus* in domestic sheep from Idaho shipped to California was found by Ruppanner and Schwabe (1973). Foci of *E. granulosus* in domestic sheep and dogs were identified in Utah and California by Williams et al. (1971) who assumed that the parasite probably existed in Idaho, since similar ecological conditions were present. A large foci of *E. granulosus* in domestic sheep and dogs has been well documented in Utah with some possible connections to both California and Idaho (Crellin et al. 1982). Based on these reports, it appears that a domestic biotype of *E. granulosus* was present in Idaho, circulating between domestic sheep and dogs, decades prior to wolf introduction.

The Idaho Department of Fish and Game has been conducting disease surveillance and disease investigations since 1998. The Wildlife Health Laboratory conducted necropsies on 164 wolves between 2005 and 2009. No evidence of *E. granulosus* was found on direct smears of intestinal contents or fecal flotations of wolves until 2006. Necropsy and laboratory tests for diagnosis of this and other wildlife diseases are on-going and continue to confirm the findings of Foreyt et al. (2009).

In Idaho, *E. granulosus* was first found in 2006 when two hydatid cysts were found in the lungs of a mountain goat from near Atlanta. Since that time, hydatid cysts have been found in the lungs of numerous deer and elk from central Idaho. The Idaho Department of Fish and Game is unaware of hunter reports about hydatid cysts in deer or elk prior to 2006.

A total of 63 intestinal tracts from wolves that were lethally removed by USDA Wildlife Services personnel or hit by vehicles between 2006 and 2008 were submitted to the Washington Animal Disease Diagnostic Laboratory for detection of *E. granulosus*. Of these, 39 (62%) were found to be infected with the parasite (Foreyt et al. 2009). A comparable number of wolves from Montana from the same time period showed a similar prevalence of *E. granulosus* (Foreyt et al. 2009).

Reporting of *Echinococcus granulosus* in Idaho

Echinococcus granulosus in animals was a reportable disease in Idaho in 2006, but is not currently on the list of reportable diseases in animals. When the parasite was found in the mountain goat in 2006, the Wildlife Health Laboratory supervisor and the Wildlife Bureau Chief were notified. The disease was reported to the state veterinarian at the Idaho State Department of Agriculture. When additional hydatid cysts were found in deer and elk, these were also reported to the Wildlife Bureau and the state veterinarian. Because of the possible zoonotic potential of this parasite, these findings were also reported to the Idaho Department of Health and Welfare. The Idaho Department of Agriculture was notified about all preliminary results in the Foreyt et al. (2009) paper and received a copy of the final published paper.

Echinococcus granulosus in humans is not a reportable disease in Idaho. Therefore, the presumed lack of human reports may not reflect the actual number of cases in the state.

Human infections with *Echinococcus granulosus*

Echinococcus granulosus and *E. multilocularis* are well documented as zoonotic diseases of humans with a worldwide distribution. The human infection with the northern biotype of *E. granulosus* is relatively benign (Rausch, 2003) and causes hydatid cysts, most commonly in the liver and lungs (Meltzer et al. 1956, Wilson et al. 1968; Gottstein 1992), but is known to occur worldwide. Human infection with the domestic biotype of *E. granulosus* is considered to be more severe than the northern biotype (McManus et al. 2002), largely due to the potential for brain involvement. Most of the reported

human cases occur in northern North America, Central America and South America (Williams et al. 1971).

In Idaho, several reports of human infections with *E. granulosus* are known. An Idaho native was found to have a liver hydatid cyst after he moved to Louisiana (Sawitz 1938). An infant with hydatid cysts in the brain was reported in 1948 (Ing et al. 1998). A young college student that grew up in rural Idaho and had contact with rural communities in Alaska was diagnosed with a pulmonary hydatid cyst and treated in Louisiana (Burlew et al. 1990). There may be other cases from Idaho that are not well documented, but these cases occurred prior to wolf introduction.

One of the more common sources of infections of this parasite in humans is exposure to infected dogs that are passing eggs in the feces. Given the relatively close bond and living arrangements with dogs, humans can be exposed to dog feces on a relatively regular basis. The eggs of *E. granulosus* are relatively resistant to environmental conditions and may be present in dried feces and the immediate area around feces.

Control of parasite infections in wild animals is difficult to unfeasible. However, because most human infections are associated with infected dogs, regular anthelmintic treatment of domestic dogs and cats and good hygienic practices by humans in contact with them are the best methods of control and prevention for echinococcosis in humans (Williams et al. 1971; Loveless et al. 1978; Eckert et al. 2000). The feeding of uncooked meat and organs of wild ungulates or domestic livestock to dogs should not be done because the ingestion of the immature forms of *E. granulosus* and other tapeworms like *Taenia* spp. in domestic sheep or elk and deer could lead to the development of adult tapeworms in the dogs. The infected dogs can then possibly expose humans to tapeworm eggs in dog feces.

The potential for human exposure to eggs of *E. granulosus* in the feces of infected wolves or fecal contaminated hides is relatively low. The extent of the interactions between most humans in Idaho and wolves is minimal as are the encounters with wolf feces. Wolf hunters are encouraged to wear latex or rubber gloves when field dressing and skinning wolves in line with the recommendations for handling carcasses of other wildlife as outlined below.

The Idaho Department of Fish and Game routinely recommends that IDFG personnel and hunters take simple precautions to maintain appropriate hygiene and minimize the potential for human exposure to pathogens that may occur in wildlife within the state (IDFG Game Care brochure 2002). These recommendations include the following:

1. Do not harvest obviously sick animals
2. Wear latex or rubber gloves when field dressing wildlife
3. Cool the carcass of the animal as quickly as possible after the animal is harvested
4. Process the carcass as soon as possible after the animal is harvested using clean equipment
5. Cook the meat thoroughly prior to eating

Potential sources of *Echinococcus granulosus* in Idaho

1. Present at low prevalence in coyotes, foxes and other canids and cycling in wild cervids prior to wolf introduction, with spread of the parasite by expanding wolf populations

2. Present in domestic dogs and sheep and spill over to wolves and cervids following wolf introduction

3. Introduced with wolves despite anthelmintic treatment of captured individuals prior to release in Idaho

4. Introduced with natural migration of wolves into Idaho and Montana from Canada